

APPLE

Cost of Brick Pavements

Civil Engineering

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COST
OF
BRICK PAVEMENTS

BY
CHARLES APPLE

THESIS
FOR
DEGREE OF BACHELOR OF SCIENCE
IN
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UNIVERSITY OF ILLINOIS

June 1, 1903₁₉₀

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

CHARLES APPLE

ENTITLED COST OF BRICK PAVEMENTS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering.

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COST OF BRICK PAVEMENTS

A considerable amount of first-class brick pavement was built in the residence portion of Champaign during the summer and fall of 1902. The construction was still in progress at the beginning of the university year in September, and as the work could easily be visited at different times during the day, the writer thought it worthwhile to attempt to get at first hand some data on the cost of the details of the work, particularly as there are very little available data on the subject.

A record was kept of the progress of the work from day to day, the amount of material used, the number of men employed, and the occupation of each. These results were checked by comparison with notes kept by Mr. O. L. Gearhart, the city inspector, and were also compared with data furnished by Mr. E. S. Meade, who acted as superintendent of construction for the contractor. The information obtained from these three independent sources agrees very well, and it is believed that the values here presented are reliable.

Most of the pavements,-- all of those in the residence district, have a combination concrete curb and gutter, and in all the districts they have a 6-inch foundation of natural cement concrete. The wearing surface of all streets paved last fall is composed of paving blocks burned from Indiana clay.

The location and extent of the work was as shown in Table I.



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TABLE I

Location and Amount of Work

| Street Paved | Portion | | Grading cu. yds. | Concrete Curb and Gutter Lin. ft. | Brick Paving sq. yds. |
|---------------------|------------|------------|---------------------|--|-----------------------------|
| | From | To | | | |
| South Wright | City limit | Daniel | 1065 | 1786.3 | 2303.0 |
| Springfield Ave. | Prospect | Wright | 10250 | 16076.3 | 24200.0 |
| West Park | Prospect | Elm | 3000 | 4302.8 | 6501.1 |
| West Park | Neil | State | 1400 | 1953.5 | 3291.5 |
| Hickory | Church | Washington | 1000 | | 2208.0 |
| | | | 16715 | | 38503.6 |

The quantities given above were obtained from the city engineer, Mr. W. H. Tarrant, and are the ones on which final settlement was made.

The contract price for the construction of the curb and gutter complete was 45 and 46 cents per lineal foot, the two prices being for different contracts. This price included all necessary excavation, material and labor. The grading for the pavement proper, by which is meant the part of the street between gutters, was let at 23 cents per cubic yard for a maximum haul of 2000 feet. The pavement itself, including concrete base, sand cushion and brick wearing surface, was let at \$1.28 and \$1.29 per square yard.

Concrete Curb and Gutter

A combination concrete curb and gutter was used on all the work, except the short section on Hickory street, which is in the business district, where a stone curb was used.

The consideration of cost will be confined to combined con-

crete curb and gutter, since it composed so large a part of all that was built.

Since the contract for the concrete curb and gutter was independent of that for the other parts of the work, and since the curb and gutter was practically a separate piece of construction, it was built before anything was done on the grading and the paving proper. This arrangement was very fortunate for the writer, in that it gave almost ideal conditions for obtaining unit costs for this part of the work.

The cross section of the curb and gutter and the arrangement of the materials in it were made as shown in Fig. 1.

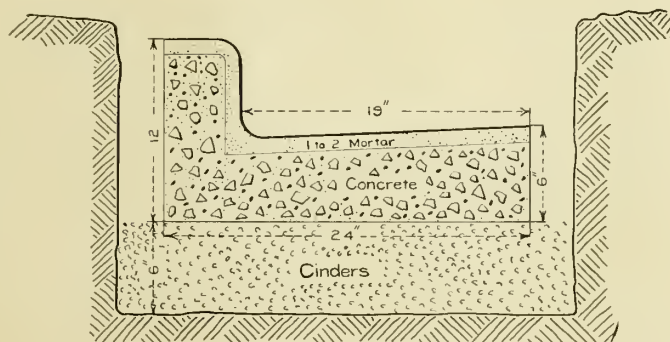


Fig. 1. Cross Section of Combined Concrete Curb and Gutter

In order to allow room for the workmen to set the forms, the trench was made about 30 inches wide, and with a depth which depended upon the street grade, but which in Champaign averaged between 15 and 20 inches. The trench was excavated with pick and shovel at a rate of one cubic yard per man per hour, in a black loam with a clay subsoil such as is found in the "Corn Belt," the earth being simply loosened and thrown out to one side.

The foundation and sub-drainage consisted of a layer of cinders, 4 to 6 inches thick, well tamped in the bottom of the trench.

The curb and gutter was constructed on this foundation in alternate sections, each 7 feet in length. The base was made of a concrete composed of one part by bulk of Portland cement and five parts by bulk of rather fine gravel and broken stone. A finishing coat one inch thick, composed of one part Portland cement and one and one half parts of sharp sand, was applied to all finished surfaces before the cement in the base had begun to set.

The various items of the cost of the curb and gutter work were as shown in Table II, which; however, does not include interest, depreciation, or general supervision, but does include freight and teaming.

Grading

No attempt will be made to take up in detail the cost of grading, since this subject does not affect materially the cost of brick pavements. Drag scrapers, wheel scrapers, and wagons were used as the length of haul demanded. When wheel scrapers were used one man loaded for six to eight scrapers, and another man on the dump unloaded.

One feature of the work which is a little out of the ordinary was that the contractor used twelve men per wagon when loading with shovels. This enabled him to keep his teams moving the greater part of the time and very materially reduced the cost of the work. The author was unable to obtain data which would indicate in dollars and cents just how much the work was thereby cheapened, but it is very evident that a team which is kept moving three quarters of the time will do more work than one which is moving only one half of the time or less.

The earth was loosened with plows to within 3 inches of subgrade. The last 3 inches were removed with pick and shovel at an

TABLE II

Cost of Concrete Curb and Gutter

| Item | No. of Men | Lin. ft. per day | Total Wages | Cost per 100 ft. | Total |
|---|----------------------|------------------|-----------------------------|------------------|----------------|
| Labor: | | | | | |
| Opening trench 18" x 30" | 2 | 144 | \$3.50 | \$2.43 | |
| Placing and tamping cinders | 2 | 350 | 3.50 | 1.00 | |
| Setting forms | | | | | |
| Boss setter | 1 | | 3.00 | | |
| Assistant setter | 1 | | 2.00 | | |
| Laborer | $\frac{1}{3}$ | 400 | $\frac{1.75}{3}$ \$6.75 | 1.69 | |
| Mixing and placing concrete | | | | | |
| Clamp man | 1 | | \$1.75 | | |
| Wheelers | 3 | | 5.25 | | |
| Mixers | 4 | | 7.00 | | |
| Tampers | 1 | | 1.75 | | |
| Finish mixers | 2 | | 3.50 | | |
| Foreman and boss finisher | 1 | | 4.00 | | |
| Assistant finisher | 1 | | 3.00 | | |
| Water boy | $\frac{1}{14}$ | 350 | $\frac{.50}{14}$ \$26.75 | \$7.64 | |
| Total for labor for 100 ft. | | | | | \$12.76 |
| Material for 100 linear feet | | | | | |
| | Amt. | | Price | | |
| Portland cement | $8\frac{1}{3}$ bbls. | | \$1.85 | \$15.42 | |
| Cinders | 7.5 c.yd. | | .50 | 3.75 | |
| Gravel | 2.5 " | | 1.00 | 2.50 | |
| Broken stone | 2.5 " | | 1.40 | 3.50 | |
| Sand | 1 " | | 1.00 | 1.00 | |
| Total for material per 100 ft. | | | | | \$26.17 |
| Total for material and labor per 100 ft. | | | | | \$38.93 |

average cost of 2 cents per square yard, with labor at \$1.75 per day of 10 hours.

The total amount of grading as shown by Table I was 16,715 cubic yards, and the contract price was 23 cents per cubic yard, making a total cost of \$3844.45 for earth work; and since there were 38,503.6 square yards of pavement, the cost to the city for excavating the foundation was 9.98 cents per square yard of paved surface.

The subgrade was compacted with a horse roller weighing 150 pounds per lineal inch. The cost of this work averaged about 0.05 cents per square yard.

Concrete Foundation

Upon the subgrade, surfaced and compacted as above, was laid a concrete foundation which was six inches thick after consolidation. The concrete was composed of one part by bulk of natural cement, three parts by bulk of sand and gravel, and three parts by bulk of broken stone, broken to such size that it would pass through a 2" ring.

The materials were placed upon the mixing board and turned with shovels until well mixed, water enough being added to produce a concrete which would show a slight flush of mortar on the surface when well tamped. The mixture was then shoveled directly from the board into place, graded and tamped.

The thickness of the layer was determined by means of pegs driven into the subgrade, their height being determined by means of a templet, which had a bearing at the center of the street on a stake set to the proper grade and at the edge of the pavement on the finished curb and gutter.

All material for the concrete was placed at intervals along the

street ahead of the work, and was brought to the concreting gang in wheelbarrows, which served as a means of measuring as well as of transporting the ingredients. The mixing was done on a steel plate, which the contractor claims makes the work easier on the men and gives a better grade of concrete because it is more thoroughly mixed. The cost of the various steps in the work is given in Table III, which is based on a 10-hour day.

Brick Wearing Surface

When the concrete base had set a sand cushion 1 1/4 inches thick was placed upon it, and upon this cushion the brick wearing surface was laid. The sand was spread and graded at the rate of 30 cubic yards per man per day, which with labor at \$1.75 gives a cost of 5.83 cents per cubic yard. One cubic yard of sand covered on the average about 36 square yards of pavement; and hence the cost per square yard for spreading and grading was 0.162 cents.

The writer could scarcely expect the contractor to reveal the price of the brick, but it will be assumed at \$16.00 per thousand delivered on the track at Champaign. There remains then to determine (a) the cost of unloading from the car into wagons, (b) the cost of haul from the cars to the work, (c) the cost of unloading from the wagons and piling at the side of the street, and (d) the cost of laying the wearing surface with brick taken from the piles just outside the curb line.

(a) The paving blocks were shipped in box cars, from which they were unloaded by ten men, eight men working in the cars and two on the wagons. These men were paid \$1.75 per day and unloaded an average of 40,000 bricks per day, which made the work cost 43.75 cents per 1,000 bricks.

TABLE III.

Cost of Concrete Base for Pavement

| Item | No. of Men | Sq. yds. per day | Total Wages | Cost per sq. yd. | Total |
|------------------------------|----------------|------------------------|------------------------------|------------------|--------|
| Labor: | | | | | |
| Rolling subgrade, 2 teams | 1 | 8000 | \$ 4.75 | 0.05¢ | |
| Mixing and tamping concrete: | | | | | |
| Turning with shovels | 6 | | 12.00 | | |
| Throwing off | 4 | | 8.00 | | |
| Handling cement | 2 | | 3.50 | | |
| Tamping | 2 | | 3.50 | | |
| Playing hose | 1 | | 1.75 | | |
| Grading concrete | 1 | | 1.75 | | |
| Wheeling stone | 6 | | 10.50 | | |
| Wheeling gravel | 4 | | 7.00 | | |
| Foreman | 1 | | 4.00 | | |
| | 27 | 900 | \$52.00 | | |
| | | | | 5.80¢ | |
| | | | Total labor per sq. yd. | | 5.85¢ |
| Material for 1 sq. yd. | Unit Cost | Amount | Total Cost | | |
| Cement | 50¢ bbl. | $\frac{1}{5}$ bbl. | 10.00¢ | | |
| Sand and gravel | \$1.00 cu. yd. | $\frac{1}{10}$ cu. yd. | 10.00¢ | | |
| Broken stone | \$1.40 cu. yd. | $\frac{1}{10}$ " | 14.00¢ | | |
| | | | | | |
| | | | Cost of material per sq. yd. | | 34.0 |
| | | | Cost for labor and materials | | 39.85¢ |

(b) The cost of haul was determined from data furnished by eight teams, which were hauling brick approximately one mile over a road which was about half good brick pavement and half fair earth roads. These teams hauled ten loads per day and were paid \$3.00 for ten hours' work. The average load was 500 blocks, making 5,000 paving bricks per team per day, which is 60 cents per thousand. It is interesting to note that in this case, where the wagons were half the time returning empty, the cost of haul was 12 cents per ton-mile, the weight of a paving block being taken as ten pounds.

(c) The 40,000 bricks hauled by these teams were unloaded and piled along the curb line by eight men, four pitching bricks from the wagons and four piling them. The men were paid the usual \$1.75 per day, and the cost of handling the bricks was therefore $\$14.00 \div 40 = 35$ cents per thousand.

(d) The bricks were taken in barrows from the piles at the curb line and dumped within reach of the brick layers by two men for each layer. The men laid 12,000 blocks per day, and were paid \$2.50 each. The wheelers received \$1.75 each per day.

Cost of wheeling 29.1 cents per thousand

" " laying 20.8 " " "

Total 49.9 " " "

For convenience this cost will be taken as 50 cents per M.

When cars could be unloaded at the same time that brick laying was in progress, the foreman had a trackway of 2-inch by 12-inch oak planks placed on the newly laid pavement and brought the loaded wagons upon it to within a few feet of where the brick layers were working. The brick were then unloaded by the men who ordinarily wheeled them from the sides of the street, and by this means the cost of unloading and piling was saved, besides making it possible

for fewer men to do the wheeling, because the bricks could be more easily loaded into wheelbarrows from the wagons than from the piles on the parking. This change in the method of working lessened the cost 1 1/2 cents to 2 cents per square yard of pavement laid.

The contractor made a preliminary inspection of the pavement and removed or turned many defective brick. The total cost of this inspection and the removal or turning of brick marked by the official inspector cost 1 cent per square yard.

The rolling of the brick was done with a horse roller at a cost of 60 cents per 1,000 square yards.

Most of the data immediately preceding are given per 1,000 brick, while the cost of the pavement is usually desired per square yard; therefore to pass from one to the other it is necessary to know the number of brick per square yard of completed pavement.

By measuring a considerable length of pavement and counting the brick, the writer found 38 3/4 brick per square yard on Springfield avenue and 39 1/2 on Wright street. The difference is not material and may have been due to wear of the molds or to the difference in the manner in which the brick layers did their work.

Table IV. shows the cost of the brick wearing surface based upon 40 bricks per square yard, which will just about allow for breakage in handling.

Legal Expenses

In addition to the costs already mentioned there is the item of legal expense, incurred preparatory to making the improvement, which will now be considered. Since this part of the cost is not a function of the number of square yards of pavement, it will not be reduced to a square yard basis as the data in the preceding article.

TABLE IV
Cost of Brick Wearing Surface

| Item | Force working | Amount of material handled per day | Total Wages per sq. yd. | Total Cost per sq. yd. |
|---|---------------------------------|------------------------------------|-------------------------|------------------------|
| Labor: | | | | |
| Spreading sand cushion | 1 man | 300 sq. yd. | \$ 1.75 | 00.57 |
| Transferring brick from cars to wagons | 10 men | 40,000 bricks | 17.50 | 01.75 |
| Hauling 1 mile | 8 teams with drivers | 40,000 " | 24.00 | 02.40 |
| Unloading at curb line | 8 men | 40,000 " | 14.00 | 01.40 |
| Wheeling brick to layers | 2 " | 12,000 " | 3.50 | 01.16 |
| Laying brick | 1 man | 12,000 " | 2.50 | 00.83 |
| Sweeping pavement, filling joints with sand, and inspecting | 1 " | 450 sq. yd. | 1.75 | 00.39 |
| Rolling pavement | 1 team | 800 " | .30 | 00.37 |
| | Total labor for 1 sq. yd. | | | 8.87 |
| Material: | | | | |
| | Amount | Price | | |
| Sand cushion | $\frac{1}{36}$ cu. yd. | \$1.00 cu. yd. | | 02.77 |
| Brick f.o.b. Champaign | 40 per sq. yd. | \$16.00 per M. | | 64.00 |
| Sand filler | | | | 00.23 |
| | Total for material for 1 sq. yd | | | 67.00 |
| Total for material and labor " 1 " | | | | 75.87 |

The legal expense consists of attorney's fees, commissioner's fees, court costs, and publication or advertising expenses. Recent court rulings in this state are that attorney's fees must be paid by the public at large and not by the paving fund, although this has not always been done. The writer attempted to find the records of the decision, but a reasonable amount of research in the law library and inquiry from attorneys failed to reveal them, so the matter was dropped.

Where the city has an engineer in its employ, he draws his salary from taxes levied on the whole city, and hence the cost of his services is not charged up to pavements. He or the board of local improvements may, however, appoint an inspector to see that the work is properly executed, and charge his time to the paving fund of the particular street receiving the benefit.

The Illinois statutes provide that "The city or village shall prescribe by ordinance whether the improvement shall be made by special assessment, by special taxation of contiguous property, or general taxation or both."

In accordance with the above statute the funds for the pavements under consideration were raised by assessing the contiguous property on a frontage basis. The city was assessed for its frontage at street intersections and in front of parks, and its share of the cost based upon this pro rata was paid out of the funds raised by general taxation.

The following is a statement of the legal expenses for each of the five jobs referred to in Table I (page 2).

TABLE V

Legal Expenses

| Items | South Wright | Spring- field | Park St. East of State | Park St. West of Elm | Hickory |
|---------------------------------|-------------------|------------------|------------------------------|----------------------------|----------|
| Attorney Fees | \$60.00 | \$200.00 | \$ 80.00 | \$100.00 | \$ 50.00 |
| Court Costs | 16.75 | 45.75 | 22.75 | 23.75 | 23.40 |
| Commissioner's Fees | 15.00 | 75.00 | 15.00 | 20.00 | 15.00 |
| Inspection | 20.00 | 264.66 | 50.00 | 114.80 | 20.00 |
| Publication | Not re- corded | 5.50 | Not re- corded | Not re- corded | 5.65 |
| Total | \$111.75 | \$590.91 | \$167.75 | \$258.55 | \$114.05 |
| Inspection Cents per sq. yd. | 0.87 | 1.09 | 1.51 | 1.76 | 0.91 |

Summary

A summary of the preceding data on the cost of the pavement proper is as follows:-

| | Cost per sq. yd. |
|--|---------------------|
| Preparing the subgrade | 9.98 cts. |
| Concrete foundation | 39.85 " |
| Brick wearing surface. | 75.87 " |
| Total exclusive of administration, superintend- ence, tools, interest, etc. | <u>125.70</u> " |

The contract price was \$1.28 per square yard for some of the streets and \$1.29 for the others.

In addition to the contract price, the abutting property was charged with the cost of inspection, which varied from 0.87 to 1.76 cents per square yard on the different streets. (See Table V.)





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